IFERP

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 6, June 2017

Failure Monitoring Analysis of Flight Control System of an Aircraft

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***Abstract*— FCS is an essential part of an aircraft, aircraft failure monitoring analysis is important. The failure of an aircraft will seriously threat its flight safety during the flight process. In order to prevent or reduce occurrence of failure, monitoring program is required. The metadologies which depicts the failure are like captions, colour-coded scheme and audio tone. By using these methods the pilots can instantly access the situation and decide on the actions to be taken. It reduces the pilot stress in abnormal and emergency situations. The information of an aircraft can be caught in the time and the corresponding remedial measures can be adopted. The data captured in terms of RS-422 is analysed using MATLAB programming language with GUI Interface.**

Index Terms—FCS(Flight Control System),Colour- Coded Scheme,RS-422,MATLAB,GUI(Graphical user Interface)

I. INTRODUCTION

The Radio Station RRF (UG) is UHF communication equipment designed to provide fast, reliable and secure telecommunication medium for Military applications. It The course of failure of an aircraft will seriously threat its flight safety features during the flight process. A manual flight control system uses mechanical parts such as rods, tension cables, pulleys, counter weights, chains to transmit the forces applied to cockpit controls. The movement of cockpit controls achieves the movement of control surfaces via the mechanical parts. Thus, the pilot's effort to control the aircraft increases as the aircraft is exposed to various atmospheric forces.

The proposed methodology is based on fly-by-wire, a fly-by-wire (FBW) system replaces manual flight control of an aircraft with an electronic interface. The movements of flight controls are converted to electronic signals transmitted by wires, and flight control computers determine how to move the actuators at each control surface to provide the expected response. Commands from the computers are also input without the pilot's knowledge to stabilize the aircraft and perform other tasks, reducing pilots stress during abnormal and emergency situations.

The signals transmitted by wires or flight data information of an aircraft can be acquired in different formats like FTI-RS 422, 1553B etc bus interface. The data captured in terms of RS-422 is analysed using conversion tool written in MATLAB programming language along with GUI Interface. The series of methodologies which represents the failures can be in form of display alert captions, colour-coded schemes on Multifunction display units and consequent audio tones. These methods displays the information about the flight parameters to the pilot, so that he can take necessary measurement avoid the occurrence of failures. The primary goal of the project was to reduce the occurrence of failures in an aircraft and to monitor failures of flight control systems leading to unprecedented levels of safety and survivability for civil and military aircraft.

II. LITERATURE SURVAY

In last 60 years, there have been many epidemiologic studies examining factors related to aviation crashes. Excluding environmental factors, the term pilot-related factors, rather than human factors is used because human factors in aviation are not limited to pilots-cockpit and cabin crew as well as air traffic control personnel also an important role. The aircraft suffers an explosive decompression from an incorrectly repaired aft pressure bulkhead, which failed in mid flight, destroying most of its vertical stabilizer and severing all of the hydraulic lines. Aircraft monitoring usage and managing the fleet was based on analog display system. Here, the mechanical system was used.

2.2.1 Analog system

All "fly-by-wire" flight control systems eliminate the complexity, the fragility, and the weight of the mechanical circuit of the hydromechanical or electromechanical flight control systems each being replaced with electronic circuits. The control

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Vol 4, Issue 6, June 2017

mechanisms in the cockpit now operate signal transducers, which in turn generate the appropriate electronic commands. These are next processed by an electronic controller-either an analog one, or (more modernly) a digit alone. Aircraft and spacecraft autopilots are now part of the electronic controller. It was mainly with the mechanical systems.

2.2.2 Mechanical system

Mechanical or manually operated flight control systems are the most basic method of controlling an aircraft. In the early 1970's, cockpit of fighter aircraft were equipped with analog meters, indicators and gauge. These aircrafts were capable of flying at less speed and low altitude and the combating efficiency was less that resulted in easy to target them from the ground. In 1980's these drawbacks were overcome by enhancing the speed and flying altitude of an aircraft but with new challenges like enhancement of combating efficiency of pilot by reading flight information accurately for precise hitting of targets. The pilot had to take the decisions in split of seconds.

Now, the aircraft monitoring is based on digital display system. The aircrafts are fitted with intelligent instruments and the cockpit is replaced with glass cockpit in which all the analog meters, indicators and gauges replaced with digital display systems. A glass cockpit is embedded with various line replaceable units (LRUs) such as Mission computer(MC), Angle of Attack(AOA), Multifunction key board(MFK), Multi Function Display(MFD), Head Down Display(HDD), HUD display, etc.

Normally, in this era, digital display system is used which is based on digital fly-by-wire system.

2.3 Digital fly-by-wire system

Fly-by-wire (FBW) is a system that replaces the conventional manual flight controls of an aircraft with an electronic interface. The movements of flight controls are converted to electronic signals transmitted by wires (hence the fly-by-wire term), and flight control computers determine how to move the actuators at each control surface to provide the ordered response. The fly-by-wire system also allows automatic signals sent by the aircraft's computers to perform functions without the pilot's input, as in systems that automatically help stabilize the aircraft, or prevent unsafe operation of the aircraft outside of its performance envelope.

III. METHADOLOGY

The performance verification and validation of an aircraft is with respect to identification of any potential failure and its consequence is made through.

1. Functional Hazard Assessment (FHA)
2. Failure Mode and Effects Analysis (FMEA)

1. FUNCTIONAL HAZARD ASSESSMENT(FHA) :

The Functional Hazard Assessment (FHA) is a safety assessment technique. Functional Hazard Assessment is a systematic, comprehensive examination of functions to identify and classify failure conditions of those functions according to their severity.

2. FAILURE MODE AND EFFECTS ANALYSIS (FMEA):

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service. "Failure modes" means the ways, or modes, in which something might fail.
Analysis are carried out:

i. As a single parameter failure.
ii. In combination with one or several other failures.

System failures which are monitored are reflected by maintenance message displayed by the Centralized Fault Display System (CFDS) or the Central Maintenance System (CMS).

Centralized fault display system: The purpose of the Centralized Fault Display System (CFDS) is to make the maintenance task easier by displaying fault messages in the cockpit and permitting the flight crew to make some specific tests.

Central maintenance system (CMS):The units, components and associated system which interfaces with multiple aircraft systems .Contains checkout and fault isolation procedures using a central computer complex and standard fault isolation procedures to locate a single system or component malfunction.

Depending on their consequence, system failure may require flight crew attention in the cockpit through the Electronic Centralized Aircraft Monitoring (ECAM):

ECAM warning
ECAM caution
ECAM audio tone

Electronic Centralized Aircraft Monitoring ECMA: An electronic centralized aircraft monitor (ECAM) is a

system that monitors aircraft functions and relays them to the pilots. It also produces messages detailing failures and in certain cases, lists procedures to undertake to correct the problem.
Additional attention getters are available in the cockpit.
ECAM System Display

i. Advisory
ii. Amber indication

ADVISORY: A mode of control under which the aircraft commander selects his own speed, altitude and heading, and has freedom of action to accomplish the assigned task.

AMBER INDICATION: Project progress reports often use the traffic light rating system. It defines as a visual cue to project performance. .. An inappropriate AMBER rating can lead to issue avoidance and ultimately project failure. Its purpose is to show progress and make it clear when board intervention is needed.

IV. BLOCK DIAGRAM

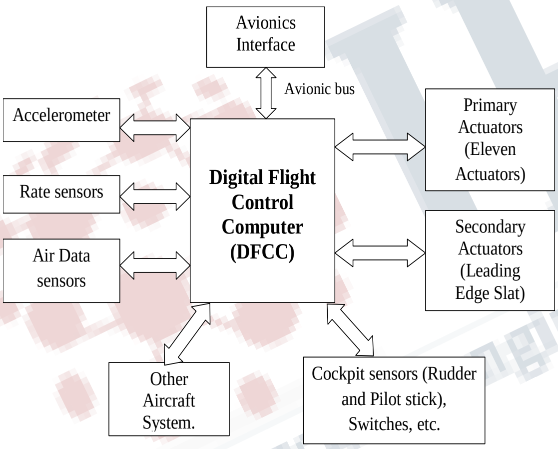

Fig. 4.1 Block Diagram

All FCS sub-systems (Sensor, Actuators, etc,) are powered by DFCC, to have common power reference/ground for the complete system. The chassis reference ground is used in order to have better ground reference for the complete system. The limitations of centralized configuration are like, increased hardware design complexity in DFCC due to implementation of all interfaces (sensor excitation and signal conditioning, actuators drive electronics and in lime monitoring, etc), handling of large electrical power by DFCC to power complete FCS units like sensors, actuators etc. This makes computer bulky, heavier with forced air cooling design and leading to maintainability issues on aircraft. Some of the other limitations are,lack of modularity for ease of up gradation with technology insertion and scalability, complexity in system maintenance, so on. These limitations can be overcome with architectural improvements and by adopting suitably new technologies. These system limitations are addressed through a distributed architecture for advanced FCS.

DIGITAL FLIGHT CONTROL COMPUTER (DFCC): A conventional fixed-wing aircraft flight control system consists of flight control surfaces, the respective cockpit controls, connecting linkages, and the necessary operating mechanisms to control an aircraft's direction in flight. Aircraft engine controls are also considered as flight controls as they change speed.

AVIONIC INTERFACE: Avionics are the electronic systems used on aircraft, artificial satellites, and spacecraft. Avionic systems include communications, navigation, the display and management of multiple systems, and the hundreds of systems that are fitted to aircraft to perform individual functions.

AVIONIC BUS: In computer architecture, a bus is a communication system that transfers data between components inside a computer, or between computers. This expression covers all related hardware components (wire, optical fiber, etc.) and software, including communication protocols.

ACCELEROMETER: An accelerometer is a device that measures proper acceleration, proper acceleration is not the same as coordinate acceleration (rate of change of velocity). Highly sensitive accelerometers are components of inertial navigation systems for aircraft and missiles.

RATE SENSOR: It is the device that measures a vehicle's angular velocity around its vertical axis.

AIR DATA SENSOR: An air data computer (ADC) is an essential avionics component found in modern glass cockpits. This computer, rather than individual instruments, can determine the calibrated airspeed, Mach number, altitude, and altitude trend data from an aircraft's pilot-static system.

PRIMARY ACTUATOR: Mechanical or manually operated flight control systems are the most basic method of controlling an aircraft. They were used in early aircraft and are currently used in small aircraft where the aerodynamic forces are not excessive.

A control yoke (also known as a control column), centre stick or side-stick (the latter two also colloquially known as a control or joystick), governs the aircraft's roll and

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 6, June 2017

pitch by moving the ailerons (or activating wing warping on some very early aircraft designs) when turned or deflected left and right, and moves the elevators when moved backwards or forwards.

SECONDARY ACTUATOR: secondary controls available to give the pilot finer control over flight or to ease the workload. The most commonly available control is a wheel or other device to control elevator trim, so that the pilot does not have to maintain constant backward or forward pressure to hold a specific pitch attitude other types of trim, for rudder and ailerons, are common on larger aircraft but may also appear on smaller ones).
Many aircraft have wing flaps, controlled by a switch or a mechanical lever or in some cases are fully automatic by computer control, which alter the shape of the wing for improved control at the slower speeds used for take-off and landing. Other secondary flight control systems may be available,including slats, spoilers, air brakes and variable-sweep wings.

COCKPIT SENSOR: The cockpit of an aircraft that provide the pilot with information about the flight situation of that aircraft, such as altitude, airspeed and direction. a space, usually enclosed, in the forward fuselage of an airplane containing the flying controls, instrument panel, and seats for the pilot and copilot or flight crew.

OTHER SENSORS: Other aircraft systems like artificial satellite, radar, automotive, temperature sensors, thermocouples, proximity sensors, touch sensors, RTD sensors etc.

V. SOFTWARE DISCRIPTION

MATLAB:

MATLAB stands for MATrix LABoratory and the software is built up around vectors and matrices. MATLAB is a software package that lets you do mathematics and computation, analyse data, develop algorithms, do simulation and modelling and produce graphical displays and graphical user interfaces. We can store the typed input into a file and tell matlab to get its input from the file. Such files must have the extension ".m". They are called m-files. If an m-file contains matlab statements just as you would type them into matlab, they are called scripts.M-files can also accept input and produce output, in which case they are called functions.

The MATLAB environment consists of menus, buttons and a writing area similar to an ordinary word processor. There are plenty of help functions that you are encouraged to use. The writing area that you will see when you start MATLAB, is called the command window. In this window you give the commands to MATLAB. For example, when you want to run a program you have written for MATLAB you start the program in the command window by typing its name at the prompt. The command window is also useful if you just want to use MATLAB as a scientific calculator or as a graphing tool. If you write longer programs, you will find it more convenient to write the program code in a separate window, and then run it in the command window.The commands you type in the command window are stored by MATLAB and can be viewed in the Command History window. To repeat a command you have already used, you can simply double-click on the command in the history window, or use the <up arrow> at the command prompt to iterate through the commands you have used until you reach the command you desire to repeat. It is also a programming language, and is one of the easiest programming languages for writing mathematical programs. It also provide Graphical User Interface(GUI) for creating user interface using which one can interact with the system.

GRAPHICAL USER INTERFACE(GUI)

GUIDE is the MATLAB graphical user interface(GUI), that allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation, instead of text based user interfaces. It provides a set of tools for creating graphical user interfaces (GUIs). These tools simplify the process of laying out and programming GUIs. GUIs provide point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application.

5.1 Creating a MATLAB GUI with GUIDE

GUIDE provides tools to design user interfaces for custom apps. Using the GUIDE Layout Editor, you can graphically design your UI. GUIDE then automatically generates the MATLAB code for constructing the UI, which you can modify to program according to our specifications.Type GUIDE in the command window, we wil get GUIDE Quick Start menu.Select Create New GUI and go to Blank GUI.

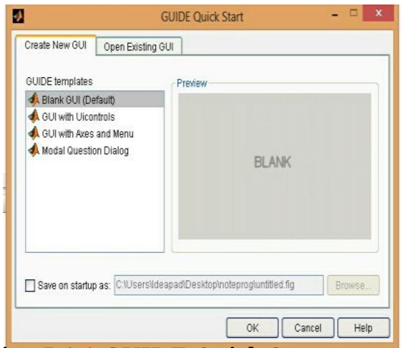

Fig . 5.1.1 GUIDE Quick Start menu

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ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 4, Issue 6, June 2017

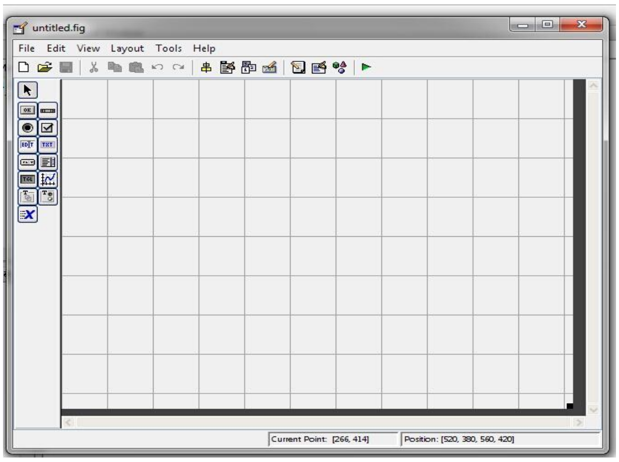


Fig. 5.1.2 GUI Starting Window

Select the required tools for creating GUI, available in the left corner according to the specification required. Drag them into the blank space and arrange them according to the requirements. The properties of the tool can be changed according to our specifications. When the user interface is created we should save that, then the MATLAB code is automatically generated and we add some more instructions to make it work according our specifications.

GUI COMPONENTS USED

PUSH BUTTON: It generates an action when clicked i.e. it appears depressed when clicked; when released the mouse button, the push button appears raised.

EDIT TEXT: It enables the user to enter or modify text strings. Users can enter numbers but it must be converted to their numeric equivalents.

VI. PARMETERS

PITCH RATE:

The pitch rate defines rate at which pitch movement from one position to another with respect to lateral axis.

ROLL RATE:

The roll rate defines the rate at which roll movement from one position to another with respect to longitudinal axis.

YAW RATE:

Yaw rate defines the rate at which horizontal or yaw movement from one position to another position with respect to directional axis.

LATERAL ACCELERATION:

The acceleration created when the flight corners that tend to push a flight sideways because of centrifugal force.

NORMAL ACCELERATION:

The component of lateral acceleration along z-axis also called as centripetal acceleration

PITCH STICK:

It is used to tilt backward or forward. Also it is used while landing and take off of flight by controlling Ailerons.

ROLL STICK: It is used in rotational movement of flight by controlling Elevons

RUDDER PEDAL:

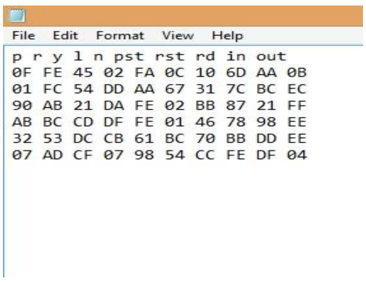
The rudder pedal is used for direction control by controlling rudder, which allows the pilot to control yaw about the vertical axis.

ELEVONS:

Elevons are aircraft control surfaces that combine the functions of the elevator (used for pitch control) and the aileron (used for roll control), hence the name. They are frequently used on tailless aircraft such as flying wings.

VII. IMPLEMENTATION

7.1 INPUTFILE



File Edit Format View Help

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p r y l n pst rst rd in out
0F FE 45 02 FA 0C 10 6D AA 0B
01 FC 54 DD AA 67 31 7C BC EC
90 AB 21 DA FE 02 BB 87 21 FF
AB BC CD DF FE 01 46 78 98 EE
32 53 DC CB 61 BC 70 BB DD EE
07 AD CF 07 98 54 CC FE DF 04
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ISSN (Online) 2394-6849

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The ranges of different parameters of an aircraft is collected using RS-422 software. The data that is received from RS-422 Software is stored in a input file. These values are in hexadecimal format, which DFCC(Digital Flight Control Computer) can't understand. These hexadecimal values are converted to engineering values by writing program in MATLAB language. The converted values are stored in another file and it made available to the GUI, so that GUI can access these values.

7.2 FAILURE MONITORIMG ANALYSIS DISPLAY

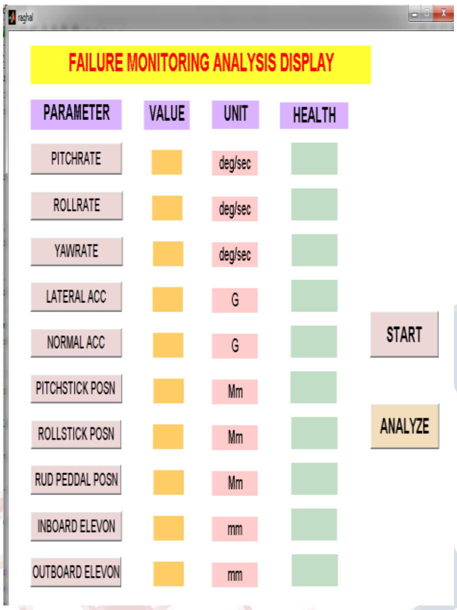
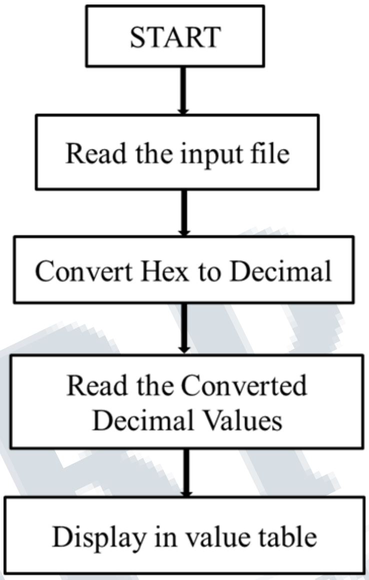


Fig. 7.2 Failure Monitoring Analysis Display

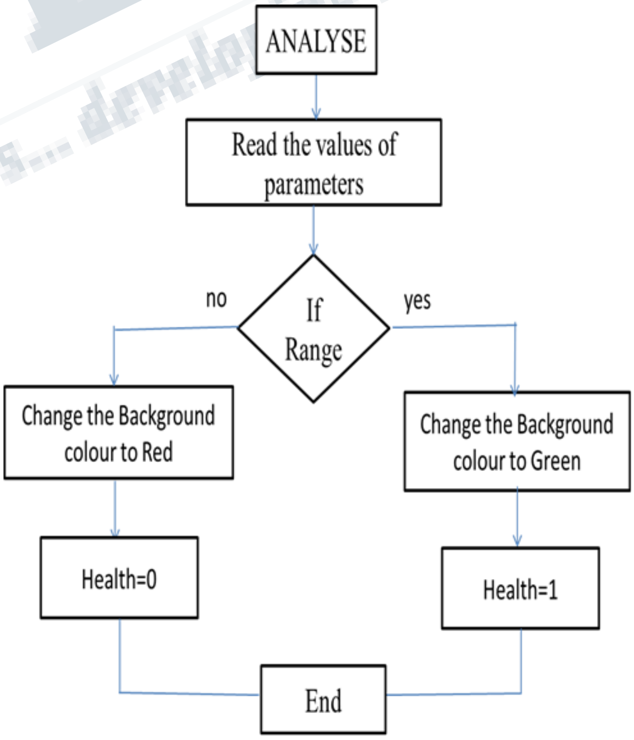
This is the failure monitoring analysis display that has been designed using GUI. It consists of Parameter table, Value table, Unit table, Health table, START button and ANALYSE button. The Parameter table, START Button and ANALYSE Button is created using Push Button. Value table, Unit table and Health table is created using Edit Text Box. When the start button is pressed the input file is read. The values of parameters are converted hexadecimal to decimal and stored in a file. These converted values are read by GUI and displayed in the value table. When we press the analyze button it will read the values of parameters. If the values of the parameters are within the specified normal range then the background color of the parameter pushbutton will change to green. If the values of the parameters are out of specified normal range then the background color of the parameter pushbutton will change to red. The program will be terminated after verifying all the values.

VII. SOFTWARE ALGORITHM

1. Flow chart for start button



2. Flowchart for analyze button

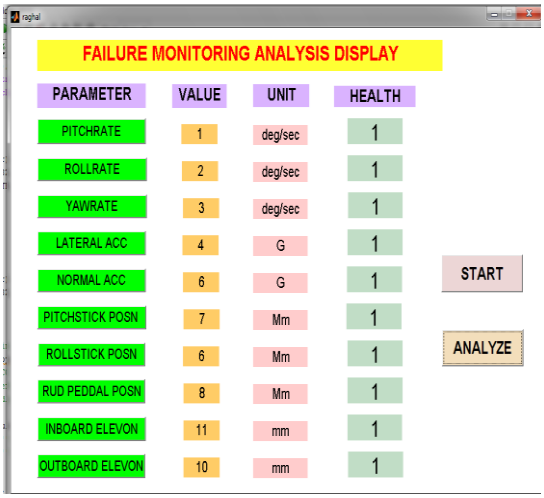


ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 6, June 2017

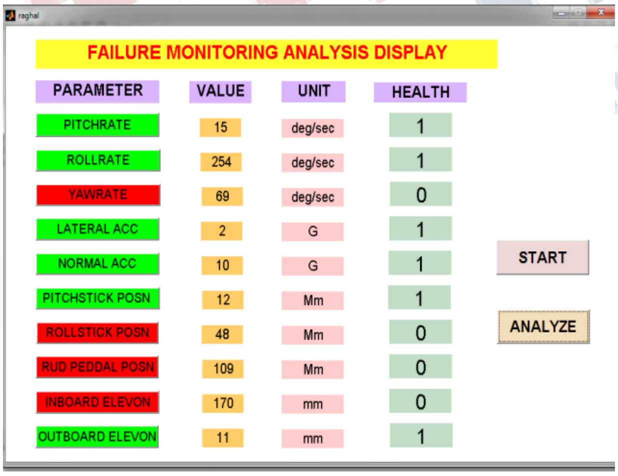
VIII. EXPERIMENTAL RESULTS

1. FMA SUCCESS



The values of all the parameters is verified individually. If all the parameter values are within the normal rang then the background color of the parameters push buttons turns to green. The corresponding health of the parameters will be ‘1’.When all the parameter values are within normal range the display will appear green and the health table will ‘1’ for all the values this condition will be called as FMA succes

2. FMA FAILURE



If any one parameter value is out of the normal range then the corresponding background color of the parameter push button turns to red. The corresponding health of the parameter will be ‘0’. When one or more parameters values are out of normal range the display and the corresponding health will appear red and ‘0’ respectively for those values, remaining parameters will appear in green color. This condition is called FMA Failure.

IX. ACKNOWLEDGMENT:

This paper and project would not have been a reality if **MRS.ANSHU DEEPAK** Assistant Professor, Dept. of Electronics and Communication, RRIT was not our mentor and guide. His guidance has been a major force in the completion of our working model. We would also like to thank **MRS. PARIMALA GANDHI** G HOD, Department of electronics and Communication, RRIT. for giving us permission to carry out this project

X. CONCLUSION

The aircraft failure monitoring analysis prevent or ease the pilot stress in abnormal and emergency situations .There is no shortage of data linking monitoring performance to safety in aviation. Investigation have shown that monitoring problems have played a significant role in individual accidents for over period of time. The studies have confirmed the positive contribution that effective monitoring makes in reducing error risk factors. Significant advancement in this area remains exclusive . In this following section we will examine what is causing hindrance and how it can be resolved.

X1. REFERENCES

1] Regenie, Victoria A. , and Duke, Eugune L. , Design of an expert –system flight status monitor, NASA TM-86739, 1985.

[2] ‘Introduction to avionics’ book by R P G Collinson(BSc Engg) originally published in 1996 pp1-6.

[3] W.Staszewski, G. Tomlinson, Boller, “Health monitoring of Aerospace structures”: Willey online library, 2004 pp137-140.

[4] Dekker, S.W.A (2001a). Follow the procedure or survive. Human factors and aerospace safety 1, 381-385.